

Growth Characteristics of the Economy

Illustrated by the Chemical Industry

ONE of the fundamental characteristics of the American economy has been and is its dynamic growth. While the expansion has been steady—cyclical fluctuations aside—at an annual rate which has approximated 3 percent in terms of the gross national product in constant prices, the forces contributing to growth have been in part foreseeable and in part unpredictable. Included in the former are such factors as population trends and growth of urban areas, while in the latter fall the results of basic discoveries and inventions, the flow of products and processes from the laboratories, and the direction of investments into new areas, new lines, and new products. Hence, it has been difficult in the past, as it is now in the present, to foresee clearly the direction from which economic stimuli to further growth will come, as well as to gauge the economic importance of products in the embryonic industrial stage, such as atomic energy. The whole history of transportation is an illustration of this point.

To set in perspective and to illustrate this important market phenomenon, a section of OBE's study "Markets after the Defense Expansion," devoted to the 1952-55 period, evaluated the role of dynamic industries in the observed growth trend. Included was a brief review of the chemical industry, and it is the purpose of this article to bring this picture up to date and to elaborate upon a prime example of twentieth century growth.

The chemical industry since the turn of the century has expanded at a rate substantially in excess of that for all output and since 1939 the rate of growth has accelerated. During the past 12 months of downward adjustment in the general level of industrial activity chemical output has shown relatively little change.

Trend of Output

The accompanying chart shows this growth. The only significant interruption to the upward trend in chemical output in the 50 years covered, apart from the temporary adjustments associated with reconversion problems following the two wars, occurred during the depression years, 1930-32. Even then the decline was less than in other segments of the economy and the subsequent recovery more rapid. For sources of data in charts on pages 10 and 11, and the method of preparing the production indexes, see the note on page 11.

All three of the broad groups of chemical manufacturing measured in the chart have undergone rapid expansion. The industrial organics group, which includes plastic materials and where the development of new products and new techniques has been especially noteworthy, has shown the fastest rate of growth.

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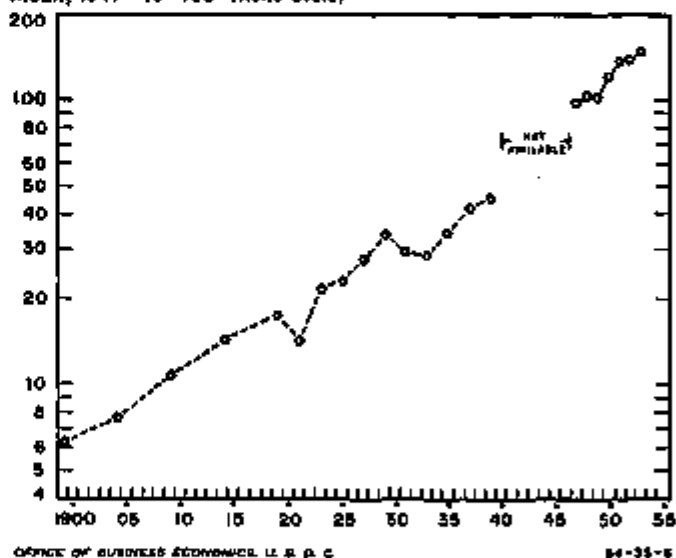
Comparative growth patterns

To appraise the role of new and established products in relation to the growth of the chemical industry, historical series were compiled for some 240 chemicals and chemical products. The listing was limited to the available output data but it is believed that the coverage is sufficiently adequate to provide the general picture.

The list comprises many new materials and products as well as the old-established lines and ranges over the entire

Production of Chemicals and Allied Products, 1899 - 1953

INDEX, 1947-49 = 100 (Roller Scale)



field of chemical manufacturing.¹ It exemplifies the wide range of products and their long-term development.

The items were classified on the basis of output from 1940 through 1953 into three broad groups—fast growing defined as those having an average rate of growth over 7½ percent per year; moderately or slowly growing which are those with growth rates up to 7½ percent per year; and the declining products. For purposes of identification, they were regrouped into three classifications—industrial organic chemicals, industrial inorganic chemicals, and other chemicals and allied products—so that they correspond to the groupings in the Federal Reserve production index of chemicals and allied products.

1. For definition of new products see note at bottom of table 2.

The diversity of trends for individual products—new and old established lines—from 1940 through 1953 can be seen from table 1. Representation of these differential movements in production is further illustrated in the chart.²

An analysis of the growth trends of these individual products and their relation to general business fluctuations reveals certain basic characteristics:

1. Many synthetic products compete with, replace, or are used as alternatives to natural products.
2. Many of the basic chemicals—acids, alkalis, sulfur, carbon black—are sensitive to changes in business cycles but after allowance for these influences they have maintained a substantial net rate of growth.
3. Most of the consumer products—soaps, cosmetics, drugs—are only little affected by fluctuations in business activity and for these items the growth rates have been below the total industry annual growth.
4. Some old-established products—such as black blasting powder and arsenate—have shown declining trends over a long period of years.

Table 1.—Production Growth Rates for 240 Chemical and Allied Products, by Major Groups, 1940-53

Annual rate of increase or decrease	Number of products			Total
	Industrial organics	Industrial inorganics	Other chemicals and allied products	
Increasing				
By 7½ percent or more	70	28	36	134
Up to 7½ percent	25	22	31	78
Decreasing	5	14	9	28
Group total	100	64	76	240

Of the 240 chemical and allied products covered, more than one-half are rapidly growing, one-third are moderately growing, and one-eighth are declining. Each of these three groups covers a variety of raw and semifinished materials and finished goods with long-established uses both for industrial and consumer purposes. New products as defined in the footnote at the bottom of table 2 accounted for over one-fourth of the total number of items in the fast-growing group, and the average rate of growth per year ranged from the very large initial advance for streptomycin to 12 percent for dichlorobenzene, ortho. Many of the new lines are still experiencing large growth rates.

A caution is perhaps in order about rates of growth since in initial periods output rises at a rapid pace which must inevitably fall as production enlarges. Consequently, the actual size of change as well as the relative size should be noted in reviewing the tables and charts.

A large proportion of the products in the fast-growing group consisted of the old-established lines. Most of the heavy basic chemicals, the so-called workhorses of the industry—caustic soda, chlorine gas, hydrochloric acid, nitric acid, phosphoric acid, ammonia, and synthetic methanol—are included in this group. The combined output of these 7 raw materials has expanded 13 percent a year since 1940.

All of the moderately or slowly growing products are old-established lines with a market life of 25 years or more. This category includes among many others the dyes, old-line medicinals and flavor and perfume materials where demand generally reflects changes in consumer income. A few of the

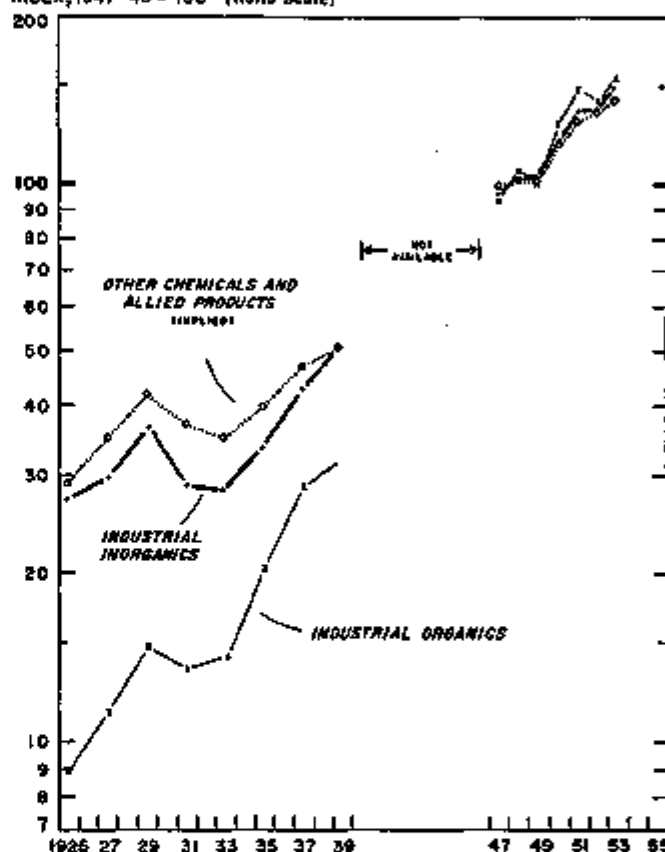
heavy basic chemicals—soda ash, sulphuric acid, benzene, and ethyl alcohol—also fall in the moderately expanding group. Production of these 4 materials combined has expanded an average of 5 percent a year since 1940.

Despite the substantial expansion in total industrial production and chemical output in particular over the past decade, there has been a slow but persistent decline in the output trends of 28 chemical products included in the list. About half of the decreases were under 5 percent a year.

Growth Trends of Major Chemical Groups

Industrial organics expand most rapidly

INDEX, 1947-49 = 100 (Ratio Scale)



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The reasons for these contrary trends vary from product to product. For example, soap has been declining steadily while the synthetic detergents have forged upward; lead and calcium arsenate have now been supplemented by the newer insecticides; zinc oxide and lead pigments have been displaced by titanium dioxide which has greater covering power; the market for black blasting powder has been taken over by high explosives (dynamite); and natural methanol and acetic acid have been almost entirely replaced by the synthetic materials.

NOTE.—For the purpose of this article, the production index has been based on the Federal Reserve Board index of "chemicals and allied products," available since the beginning of 1947, and indexes based on Census of Manufactures data for earlier periods. These were calculated for census years from 1929 through 1939 by the National Bureau of Economic Research and, for 1947 relative to 1939, jointly by the Federal Reserve and the Bureau of the Census. Production indexes are not available for the inter-census years and from 1940 through 1946.

The indexes for industrial inorganic and organic chemicals beginning in 1947 are components of the Federal Reserve index, and the "all other chemicals" index represents a combination of the remaining components of the Federal Reserve chemical index. For earlier years, the inorganic and organic chemical indexes are from the Stanford Research Institute; the "all other chemicals" index is derived as a residual from the independently calculated total index.

A comparison of the Federal Reserve and the Stanford Research Institute indexes of organic and inorganic chemical production for the years 1947 through 1949 shows that the two sets of indexes moved fairly close together despite differences in the number of products used and in the method of weighting.

² Sources of data in chart: Bureau of the Census and Business and Defense Services Administration of the U. S. Department of Commerce; U. S. Tariff Commission; Chemical Economics Handbook, Stanford Research Institute; Society of the Plastics Industry.

Table 2.—Production Trends of Selected New Chemical Products and Materials

Product	Unit of measure	Production			
		First year available		1949	1953
		Year	Quantity		
Streptomycin.....	Thous. lbs.	1946	3	3	428
Penicillin salts, total.....	Thous. lbs.	1944	3	44	724
Plastic pipe.....	Mill. lbs.	1950	5	—	30
2-4-6-T and derivatives.....	Mill. lbs.	1950	2	—	11
Polyethylene (Plastics).....	Mill. lbs.	1948	1	13	135
Rubber, GR-S.....	Thous. lg. tons	1942	2	613	695
Styrene, consumption.....	Mill. lbs.	1930	1	3	798
Polystyrene (Plastics).....	Mill. lbs.	1930	1	3	668
2,4-D acid.....	Mill. lbs.	1948	1	8	28
Rubber, butyl.....	Thous. lg. tons	1943	1	73	78
Argon.....	Mill. cu. ft.	1947	20	—	178
Isobutylene, consumption.....	Mill. lbs.	1935	1	4	129
Pentaerythritol (Polyhydric).....	Mill. lbs.	1940	1	1	56
Aliphatic amines, total.....	Mill. lbs.	1935	(*)	2	155
Synthetic detergents.....	Mill. lbs.	1935	2	28	2,134
Vitamins, total.....	Thous. lbs.	1938	9	40	5,182
Benzene hexachloride.....	Mill. lbs.	1947	8	—	57
Synthetic fibers, except rayon.....	Mill. lbs.	1939	2	5	304
Melamine (Plastics).....	Mill. lbs.	1940	1	1	63
Polymethacrylates (Plastics).....	Mill. lbs.	1939	1	2	42
DDT.....	Mill. lbs.	1945	30	—	84
Polyvinyls (resins), total (Plastics).....	Mill. lbs.	1939	24	23	516
Antibiotics, except streptomycin and penicillin.....	Thous. lbs.	1948	230	—	441
Methylene dichloride.....	Mill. lbs.	1944	9	—	54
Neoprene.....	Thous. lg. tons	1939	2	3	30
Boritol.....	Mill. lbs.	1938	1	2	126
Maleic and other non-benzenoid alkyd resins (Plastics).....	Mill. lbs.	1934	1	7	75
Perchloroethylene.....	Mill. lbs.	1940	12	12	162
Methyl chloride.....	Mill. lbs.	1935	2	2	18
N-type synthetic rubber.....	Thous. lg. tons	1941	3	—	28
Urea (Plastics).....	Mill. lbs.	1935	2	22	194
Monosodium glutamate.....	Mill. lbs.	1939	1	10	16
Concretes, insulators, and petroleum polymers (Plastics).....	Mill. lbs.	1940	34	34	597
Methylated chrysine orange (OP).....	Thous. sh. tons	1943	1	—	4
Sulfur drugs.....	Thous. lbs.	1937	365	650	4,573
Dichlorobenzene, ortho.....	Mill. lbs.	1935	1	6	15

na. Not available.

1. Data are for 1952.

2. Less than \$50,000 lbs.

3. Data are for 1954.

NOTE.—For the purpose of this analysis, new products were considered to be those which have been introduced in commercial production since 1939. It should be pointed out that the new products included in the tabulation consist in the main of chemical materials requiring further processing and, therefore, the many hundreds of final products or component parts fabricated from plastics and other chemical materials and introduced into the market in the past 25 years are not listed in the tabulation.

Sources: Bureau of the Census and Business and Defense Services Administration of the U. S. Department of Commerce; U. S. Tariff Commission; Chemical Economics Handbook, Standard Research Institute; and Society of the Plastics Industry.

The role of new products

An important factor contributing to the growth of chemical manufacturing over the long-term has been the continual development through research of a wide range of new products for both industrial and consumer use.

Thus, important new products introduced before the mid-twenties included rayon, dyes, and certain types of synthetic plastics. Ammonia and nitric acid were first produced synthetically in 1925. Neoprene, a type of synthetic rubber, and nylon were developed in the thirties. But the period since 1939 has heralded important and far reaching discoveries, stimulated and to some extent forced by the wartime conditions.

Some of these new products are well known, such as the new synthetic fibers, rubber, and detergents, antibiotics and the agricultural chemicals. Output of chemical products which were just entering commercial production in 1939 plus those subsequently introduced, account, on the basis of a rough calculation for a representative sample of some of the more important items, for about 20 percent of the Federal Reserve Board production index of chemical and allied

products, and something under 2 percent of total industrial output.

New product patterns

An analysis of the production trends of newly developed products generally shows a variety of patterns. Three basic characteristics stand out:

1. Most successful new products have shown steep and almost uninterrupted growth trends though at varying rates.
2. Many new products after a rapidly growing initial phase have continued to expand but at a considerably reduced rate.
3. Some new products after rising rapidly in the early years of production have begun to level off or have declined.

The growth rates and the magnitude of production gains for 36 relatively new products are presented in table 2. It should be pointed out, however, that a few of these products have been in production and on the market for only a short time so that their full market potentialities are still to be tested.

As might be expected, the highest growth rates appeared in the more recently developed products such as streptomycin, plastic pipe, and polyethylene, while the less rapid growth rates were experienced in those products which have had a longer life span. Even so neoprene, for example, still has a 17 percent growth rate. With few exceptions, growth rates for new products from 1950 to 1953 were considerably below the longer-term experience.

For the 36 new chemical materials and products considered as a whole, the geometric average increase has been about 40 percent. The value of output of these new lines at manufacturers' prices totaled roughly \$3.5 billion to \$4 billion in 1953. This compares with about \$100-\$150 million in 1940.

Rise of plastics

The development of the plastics industry ranks high among the technological advances that have occurred in the past decade or so. Though plastics have been produced for many years, in a sense the industry is quite young. Many of the plastic materials used in present-day manufacturing were products developed during and since the war. In fact, the last war built up the industry as plastic materials demonstrated their usefulness both in the manufacture of goods which otherwise would have required materials, such as metals or wood, which were generally in short supply, and in the creation of new end products.

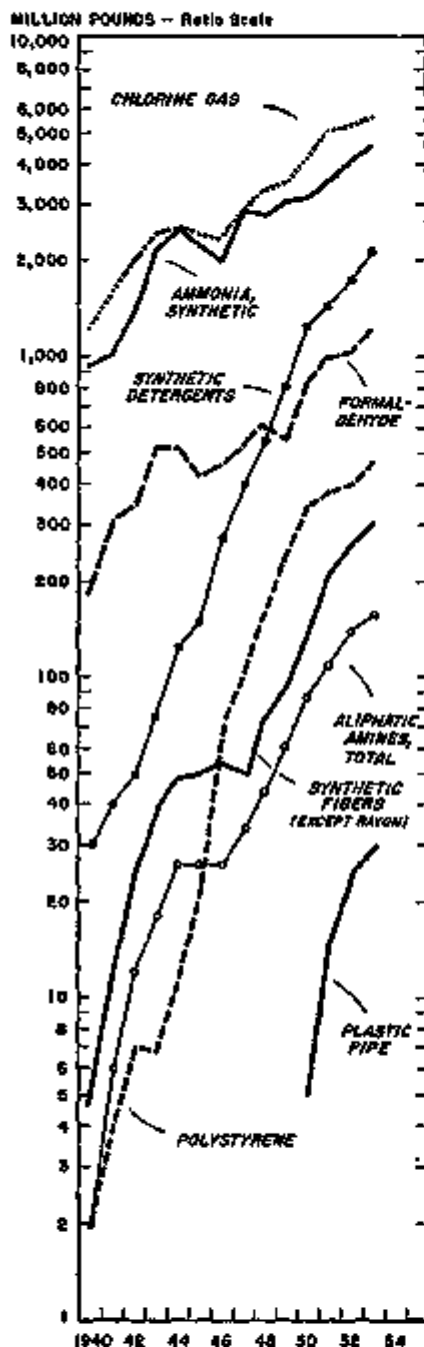
Output of plastic materials has been expanding at an average rate of about 20 percent per year since 1918. It is one of the largest areas in the synthetic organic field, accounting for close to 10 percent of the volume and 25 percent of the sales value of all synthetic industrial organics, which in 1953 totaled 29 billion pounds with a value over \$4 billion, according to reports of the U. S. Tariff Commission. Thus plastics have assumed a place of major importance in our industrial economy.

In 1919 output of plastics totaled 23 million pounds, largely cellulosic materials. Twenty years later, it had risen to 247 million pounds, and by 1953 to 2.8 billion pounds, or almost double the 1949 volume and well over 10 times the 1939 tonnage. Plastics volume, for example, approximates the present rate of aluminum production.

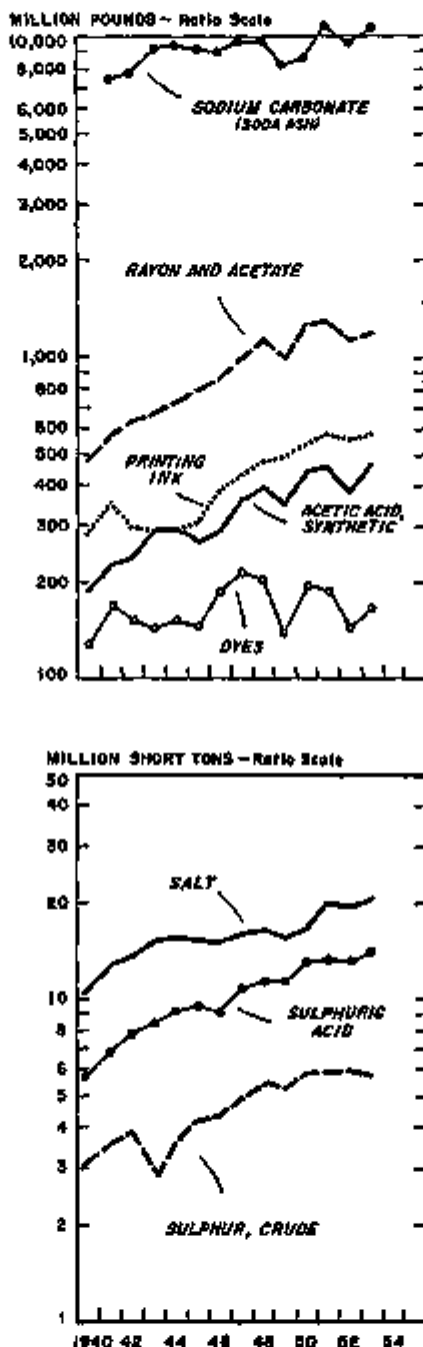
The sharply rising curve of total plastics production is depicted in the chart. The noncellulosic plastics, which account for about 95 percent of the total, have generally

PRODUCTION TRENDS OF CHEMICAL PRODUCTS

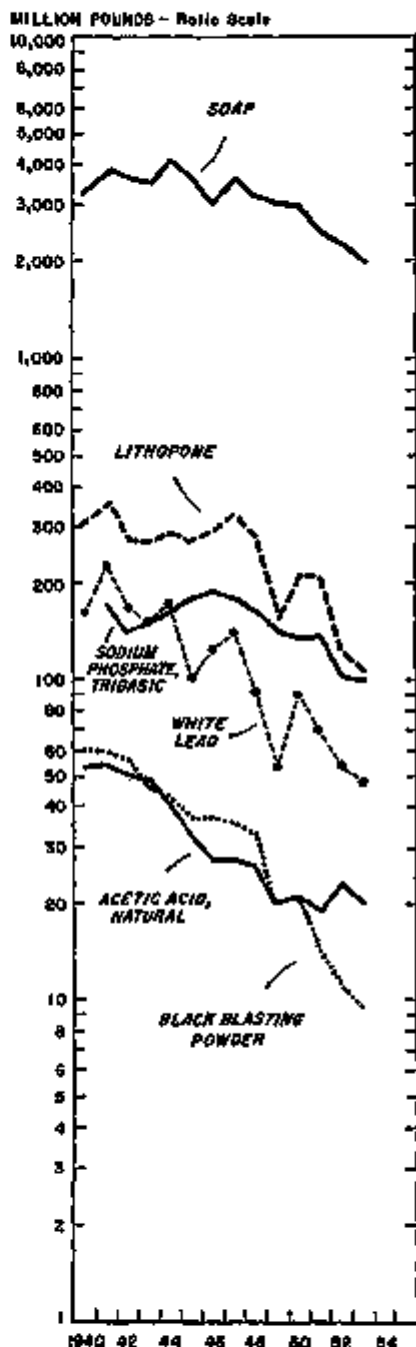
Fast Growing —
Over 7½% per annum



Slower Growing —
Less than 7½% per annum



Declining Products —



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DATA SEE TEXT FOOTNOTE 2

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followed a straight-line rapid growth trend throughout the period. The cellulose group of plastics, which are processed into finished consumer products as celluloid toys, games, buttons, and other items, have shown an irregular up-trend, with most of the rise occurring since 1941.

Many of the plastic products, a number of which are included in table 2, have reached volume production with increases in output for some of the individual materials especially striking.

The moderate dip in total output in 1952 reflected largely the adjustments which were occurring in many manufacturing industries beginning in the fall of 1951 and continuing for the most part through the first half of 1952. In 1953, plastics production reached a new peak, approximately 20 percent higher than in 1952. For the first half of this year output, while down 5 percent from the second quarter peak of 1953, was still slightly above the average for the year as a whole.

Expansion in Investment

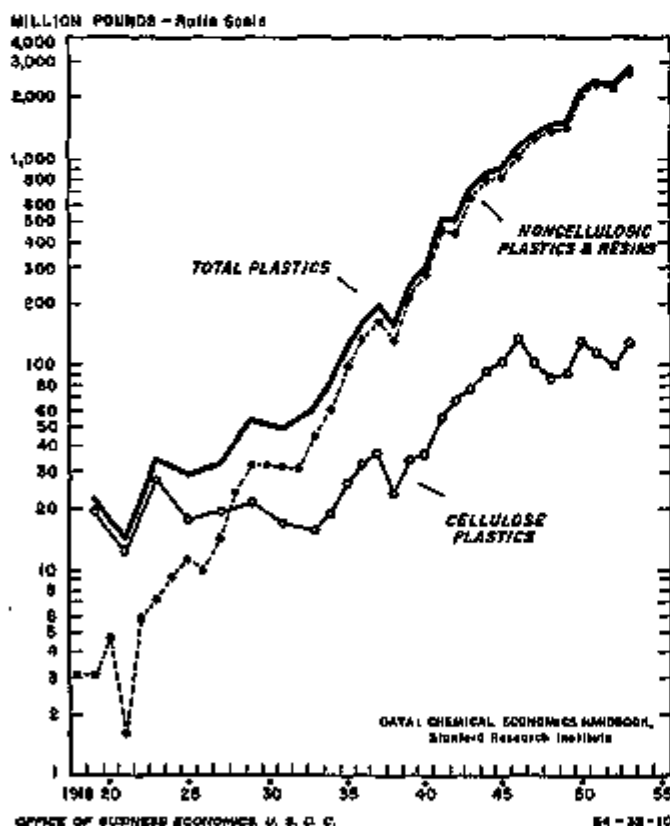
The expansion of the chemical industry has in large measure resulted from an ever increasing scale of industrial research and developmental work over the past decades. Many of the larger chemical companies, according to a 1951 survey conducted by the U. S. Department of Labor in cooperation with U. S. Department of Defense, spend for such purposes a higher proportion of annual sales than most other major industries.

The chemical industry's expenditures for new plant and equipment have kept pace with the expanding outlays for research and development of new products. This investment has been at a very high rate throughout the postwar period and particularly since 1950, when the defense program necessitated the immediate installation of greatly expanded production capacity of chemicals.

Despite the tremendous new capacity built during World War II the expanding peacetime markets for chemical products in the postwar years required additional substantial investments in new plants and facilities. From 1946 through 1953, outlays for new plant and equipment by the chemical industry averaged close to \$1.1 billion annually, aggregating \$8.5 billion over the 8-year period and representing 10 percent of the total for all manufacturing. Of this amount well over one-half was spent after 1950.

PLASTICS

Output Expands Rapidly



In the current year, investment expenditures have continued at a high rate; over \$1.3 billion will be spent. This is nearly one-fourth higher than the 1946-53 average though moderately below the record year of 1953 when close to \$1.6 billion was expended. Most of the drop this year reflects, of course, the tapering off of expenditures resulting from the completion of expansion goals set up under the facilities expansion program.

It should be noted that the investment in plant and equipment by the chemical industry also includes expenditures for facilities not related to chemical production. On the other hand, many of the petroleum companies are spending large sums of money for expansion into the chemical field which is becoming increasingly tied up with the development of petrochemicals, products derived from crude petroleum and natural gas. Similarly, many of the rubber companies are also finding it advantageous to extend their scope of operations into chemical lines through the production of synthetic rubber and related items.

Facilities programs for new products

A large proportion of the industry's investment in new plant and equipment is known to be budgeted for plants producing new products. Exact figures are not available to indicate the relative importance of expenditures earmarked for new product facilities and those set aside for established products. Figures compiled by the Bureau of the Census do suggest, however, that well over two-fifths of total expenditures for plant and equipment in the chemical industry since 1946 went into new plants producing industrial organic chemicals, the area where most of the new product development has been centered. Moreover, in a survey conducted in late 1952 by the Office of Business Economics it was indicated that large chemical manufacturing companies expected during the next several years to devote about one-half of their total investment—and three-fourths of their total expenditures for expansion—to new products.

Expansion in synthetic fibers

The record of synthetic fibers is typical of the expansion which has been associated with growth in investment.

Production of rayon and acetate, or the cellulosic fibers, amounted to 51 million pounds in 1925. By 1939 it had risen to 380 million pounds, and in 1953 the total reached 1.2 billion pounds. Rayon and acetate capacity, according to Textile Organon, has doubled since the end of the war, rising from 800 million pounds to 1.6 billion at the end of 1953. Present expansion plans call for an additional 100 million pounds by the end of 1955. It is obvious that this vast expansion is associated with a very high investment in new plant and equipment within the chemical industries and to some extent in related industries supplying raw materials.

Expenditures for new plant and equipment are not available for rayon but some indication is provided from applications for tax amortization certificates which show that a direct capital investment of about 75 cents is required for every new pound of additional rayon capacity installed.

For the noncellulosic fibers such as nylon and the more recently developed synthetic fibers the expansion of facilities has likewise been of considerable magnitude.

The production of nylon, the first of the newer fibers, began late in 1939 with a plant capacity of approximately 4 million pounds. Constant expansion of facilities during the war and the immediate postwar years brought capacity for nylon and other types of noncellulosic fibers—Dacron, Orlon, Acrilan, Dynel, and others which were introduced at varying dates shortly after the war—to around 150 million pounds in 1950, of which about two-thirds represented nylon. At the end of 1953, capacity totaled 428 million pounds and this is expected to increase by two-fifths to a total of over 600 million pounds by the end of next year, a fourfold increase in 5 years. The contemplated investment in plant and equipment for the nylon expansion program alone since 1950 has been estimated, on the basis of tax amortization certificates approved, at over \$200 million. An equal amount is indicated for the newer fibers.

(Continued on p. 28)

year, but the estimates for direct investments in Canada during the second quarter include about \$30 million for investment trusts organized in that country by American interests as a means of acquiring Canadian securities for long-term investment.

There was a considerable rise in international purchases and sales of corporate stocks, with Americans buying foreign stocks, particularly in Canada and the Netherlands, while investors in some European countries invested substantial amounts in United States stocks.

The improved supply of capital in both Canada and Europe reduced the difference between United States and foreign interest rates, and thus practically eliminated new issues of foreign securities here. During the six months ending in March these flotations had resulted in a capital outflow of \$376 million. In fact, European countries found it advantageous to reduce their long-term debts to private United States banks during the second quarter. Furthermore, since June, the Netherlands has made substantial repayments before maturity on a reconstruction loan by the International Bank, and the United Kingdom returned to the International Monetary Fund \$112 million obtained in 1947 and 1948. The International Bank found it possible to obtain an increasing proportion of its capital requirements in Europe and Canada, and in July a private American corporation floated a loan in Europe.

Short-term United States capital reversed its movements from a net return flow which had lasted all through 1953 and the first quarter of 1954 to a net outflow of over \$100 million. Most of this outflow consisted of commercial credits on exports, particularly to Brazil and Colombia. There was also an outflow of short-term funds to the United Kingdom, possibly in connection with the opening of the gold market and various commodity exchanges in that country.

Government aid

The rise in military aid during the second quarter was due mainly to increased shipments of military equipment to

Indochina prior to the conclusion of the armistice. The smaller amount of other grants included about \$65 million as budget aid to France to meet the costs of the war in Indochina and \$15 million in British currency obtained through the sale of surplus agricultural goods, which was returned as grants to the United Kingdom to further the general aims of the mutual security program.

Repayments on long-term Government credits exceeded new loans by about \$50 million, and the short-term Government capital outflow reflects largely a net increase in holdings of foreign currency or claims arising from the sale of surplus agricultural materials. Thus, Government assistance to foreign countries to overcome basic deficiencies in their economies has declined more than the figures for Government grants and capital movements indicate.

Second quarter summary

Omitting exports of military-end items supplied under military aid programs, and reducing net exports by about \$100 million to allow for the effects of the interruption of shipping during March, the balance of goods and services in favor of the United States during the second quarter amounted to approximately \$470 million. This amount was about \$120 million larger than the aggregate funds available to foreign countries from private remittances, Government transfer payments and long-term private investments. In part, therefore, United States exports during the second quarter were financed by special means such as short-term private credits or Government grants and acceptance of foreign currencies in payment for surplus agricultural products.

Except for the last quarter of 1953, which was affected by seasonally large incomes from foreign investments, this was the first time since the second quarter of 1952 that the balance due the United States on goods and services had not remained within the limit within which it could be financed without resort to such special means. On the whole, however, the position of foreign countries mirrors further economic improvement.

Growth Characteristics of the Economy Illustrated by the Chemical Industry

(Continued from p. 14)

Overall, it is estimated that the chemical industry has invested over \$1 billion for facilities to produce all types of synthetic fibers since the end of the war. By the end of 1955, additional substantial expenditures will be necessary to complete the present facilities expansion program.

The rapid large-scale development of the synthetic rubber industry provides a further illustration of the huge investment required in the development of a new product. Prior to the last war the only commercial synthetic rubber of consequence produced in this country was neoprene. This was first introduced in 1934 with production reaching only 2,000 tons by 1939. Within the space of a little over three years approximately \$700 million was invested in Government-owned synthetic rubber producing facilities having a capacity of 1,000,000 tons.

Equally impressive has been the expansion in plastics manufacture. The expansion goal calls for capacity to produce 4.6 billion pounds of plastic materials by January 1, 1955, involving a total investment of \$450 million. The goal represents an increase of 2.5 billion pounds over actual production of 2.1 billion pounds produced in 1951. This program includes all the resins which are utilized to produce civilian, defense-supporting, and certain military end items.

Government Expenditures and Income

(Continued from p. 9)

by a deficit. The differences in both cases, however, have been quite small relative to total revenues.

A major portion of the State and local new construction put in place during the past year was financed out of borrowed funds. From July 1953 through June 1954, these governments raised new capital amounting to \$6.6 billion, half again as much as in the previous year. The rate of borrowing has been unusually high since last January with the trend toward self-liquidating projects a contributing factor.

The outlook for State and local purchases is for another year of increase close to the \$2 billion postwar average annual rate. The heavy borrowings of recent months foreshadow a resumption of the long-term rising trend of new construction outlays; Federal-aid highway grants have been doubled for fiscal years 1955 and 1956, and school enrollments are up sharply again this fall, creating additional demands for teachers and school facilities. While the over-all increase in debt during the past year has been large, liquid assets held by State and local governments—mostly in sinking funds—are still rising almost as fast as the debt. The course of revenues during this same period is dependent in part upon the trend of general economic conditions, but the tax structures of these governments tend to make receipts relatively insensitive to small changes in the national product and income.